

ATMO 352: Severe Weather and Mesoscale Forecasting
Spring 2007
STUDY GUIDE – Exam #2

Date: Wednesday, 4/11/07
Time: Class period: 50 minutes, 12:40 – 1:30 PM. Please arrive a few minutes early to allow time to hand out exam.
Location: O&M, Room 103
Type: Closed book and notes. Calculator OK. *You must work independently!*

Form of Exam: Approximately three major questions with sub-parts. Midterm exams can be a mixture of objective (e.g., multiple choice, true/false) and/or subjective (e.g., short answer/definition, problem solving, derivation) questions. A typical midterm might include 1) multiple choice/true-false questions (10 minutes, 20%), 2) independent short answer questions (20 minutes, 40%), and 3) an integrated problem solving/derivation question with sub-parts (20 minutes, 40%).

Material Covered: - Lecture notes and web-page lecture materials from 2/19/07 to 4/9/07, inclusive (i.e., Chapters 3 and 4)
- Lab notes and web-page lab materials accompanying lab exercises 5 – 9.
- Required reading assignments numbers 5 – 9 as specified on the class web page (i.e., UCAR COMET MetEd modules “*Principles of Convection III*” and “*A Convective Storm Matrix*,” UI WW2010 Project modules on “*Radar Meteorology*” and “*Satellite Meteorology*,” and the NOAA SPC Internet site on “*SPC and its Products*.”). Also, the NSSL “*Severe Thunderstorm Climatology*” Internet page as it relates to the specific lab questions.

Instructional/Learning Objectives

- 1) List the three fundamental classes of convective organization.
- 2) Describe the basic properties of ordinary cells. Identify potential weather threats associated with ordinary convection.
- 3) Identify and describe the three stages of the Byers-Braham model of ordinary cell evolution.
- 4) Describe the basic properties of multicell convection. Identify potential weather threats associated with multicell convection.
- 5) Describe how multicell storms move. Define and describe verbally and graphically the system, cell and propagation vectors of motion. Describe the basic role of the mean wind, the gust front/cold pool and surface inflow in the movement of multicell convection.
- 6) Define the basic properties of supercell convection, including their structure, duration and movement, and climatology.
- 7) Identify and describe various radar and visual properties of classic supercell convection including the BWER, the hook echo, the mesocyclone, forward overhang, updraft, front/rear flank downdrafts and gust fronts, flanking line, likely tornado locations, wall cloud, likely location of various precipitation types (e.g., large hail, small hail, heavy rain, light rain).
- 8) Describe the differences in the visual and radar structure of LP, classic, and HP supercells. Given a picture or schematic, identify a supercell as LP, classic, or HP type.

- 9) Identify severe weather threats commonly associated with each supercell type.
- 10) List the two fundamental properties of the atmosphere that exert control over the intensity, organization and evolution of convective storms.
- 11) Describe the evolution of storm structure as a function of increasing low-to-mid level (0-6 km) tropospheric vertical wind shear.
- 12) Identify and describe two physical mechanisms that explain the organizational capacity of vertical wind shear. Identify the mechanism that is dominant in supercell and multicell convection.
- 13) Explain physically how a gust front can trigger new convective growth.
- 14) Given the vorticity tendency equation, describe physically and graphically the vorticity generation terms.
- 15) Given a simplified vorticity tendency equation for cumulus convection, sketch, and physically and mathematically describe the vorticity balance around an idealized developing cumulus cloud associated with a given vertical wind shear profile and cold pool orientation. Given your results, assess the cumulus scenario that is most (or least) likely to reach the level of free convection, all else being equal.
- 16) Describe the vorticity balance at the interface between two colliding cold pools/gust fronts. From this balance, infer the orientation (i.e., tilted vs. erect) and likelihood of a cumulus cloud forming and reaching the LFC.
- 17) Explain the interaction and evolution of an idealized convective cell and its cold pool in the presence of no vertical wind shear. Describe this same interaction if the environmental winds increase from zero at the surface to some moderate value at higher levels (i.e., weak-to-moderate wind shear).
- 18) Given the linear pressure perturbation term for supercells, sketch and describe (physically and mathematically) the linear dynamical effects of a strong updraft at mid-levels in a convective cell interacting with moderate-to-strong environmental shear that is either a) unidirectional, b) curved/veering or c) curved/backing. In your sketch, be sure to label perturbation low and high pressure centers and the sense of the linear perturbation pressure terms. Discuss implications for storm development and propagation (e.g., right vs. left moving storms).
- 19) Identify and describe the source of the initial vertical vorticity in a supercell storm. Identify and describe the mechanism that subsequently intensifies the vertical vorticity in a supercell storm. Identify and explain the dominant sign or sense (cyclonic vs. anti-cyclonic) of the vertical vorticity within the updraft of a right or left moving supercell.
- 20) Given the non-linear pressure perturbation term for supercells, sketch and describe (physically and mathematically) the non-linear dynamical effects of a strong updraft at mid-levels in a convective cell interacting with moderate-to-strong environmental shear. Be sure to explain the storm splitting process.
- 21) Given fundamentally (i.e., **not** subtly) different characteristics of CAPE and/or vertical shear profiles (e.g., magnitude, shape, and/or depth), identify the most likely horizontal storm structure and evolution. For example, you might be asked to match given environmental conditions with given horizontal storm structures based on your knowledge from the MetEd “convective storm matrix” module and lecture materials.
- 22) Evaluate the expected convective type (e.g., ordinary, multicell or supercell) given fundamentally different characteristics of CAPE and/or environmental shear.

- 23) Define the bulk Richardson number. Describe how it is used to forecast convective organization or type. Identify typical ranges of bulk Richardson number associated with multicell and supercell convection.
- 24) Explain what is meant by a “continuum of storm behavior” from multicell to supercell. In your answer, explain why convective organization or behavior does not necessarily fall into neat, discrete categories.
- 25) Identify the locations of climatological frequency maxima of tornado activity (F0-F5, F0-F1, F2-F5, F4-F5) in the United States. Identify the geographical region called “tornado alley.”
- 26) Identify the peak tornado producing months (or describe the annual cycle of tornado activity) in the United States. Describe the annual migration of tornado activity in the United States.
- 27) Identify the locations of climatological maxima of severe hail and wind activity in the United States. How do the locations of these maxima change if you look at very large hail (e.g., ≥ 51 mm or 2”) and very strong wind (≥ 33.5 m s⁻¹ or 65 kt)?
- 28) Describe the monthly migration of the location of severe hail frequency maxima through the spring and summer months.
- 29) Describe in basic terms how a Doppler radar sends and receives radar signals to locate a target.
- 30) Define and describe the Range Height Indicator (RHI) and Plan Position Indicator (PPI) radar scanning modes.
- 31) Describe how the radar elevation angle and range, Earth’s curvature and refraction can affect the determination of a targets location as detected by Doppler radar.
- 32) Define radial velocity and describe in basic terms how it is measured by Doppler radars.
- 33) Describe what is meant by “clear air return” and physically how the radar can identify targets in the so-called “clear air.”
- 34) Given a Doppler radar PPI image of radial velocity, interpret the image to identify the general wind pattern (i.e., trends in direction and magnitude of the wind), including both large-scale (e.g., speed shear, directional shear, fronts) and storm scale (e.g., divergence/convergence, mesocyclone, and Tornado Vortex Signature (TVS)) wind patterns and features. Describe the relationship between a radar detected mesocyclone (or TVS) and severe convective weather.
- 35) List the GOES satellite imager instrument characteristics (e.g., wavelength and resolution) associated with each channel.
- 36) Given IR and/or visible GOES imagery, identify and describe the cloud type, characteristics (e.g., cloud top temperature, low/middle/high clouds) and amount over a specified region.
- 37) Given water vapor GOES imagery, identify regions of dry and moist mid-troposphere air and locate jet streaks.
- 38) Define the GOES IR Enhanced-V (and warm wake) cloud top signatures. Given enhanced GOES IR imagery, identify the enhanced-V and warm wake signatures. List and describe the hypothesized physical mechanism(s) for these satellite IR signatures. Explain their relationship with severe convective weather.
- 39) Identify and describe the NWS/SPC severe storm guidance products and procedures (e.g., convective outlooks, mesoscale convective discussions, severe weather and tornado watches, and public severe weather outlooks).
- 40) Identify and describe the “levels of risk” utilized by SPC to provide severe storm forecasting guidance.

- 41) Describe the difference between “organized” and “pulse type” severe weather events. Identify which of these events are the primary responsibility and focus of SPC.
- 42) Evaluate the severe weather threat given CAPE and 0-6 km (deep) shear or the Craven Significant Shear Parameter (CAPE*deep shear). Justify your forecast.
- 43) Explain the role of synoptic forcing in convective pre-conditioning and initiation in your own words. Given the synoptic situation (e.g., upper air and surface data and analysis), evaluate the role of synoptic forcing in the initiation and maintenance of severe convection.